

**CLAIMS**

1. A combustion control apparatus for an internal combustion engine, comprising:
  - an exhaust purifier in an exhaust passage of the internal combustion engine;
  - a combustion controlling actuator to cause main combustion, and to cause preliminary combustion prior to the main combustion; and
  - a controller to control fuel injection to produce the preliminary combustion, and to control fuel injection to start the main combustion after an end of the preliminary combustion.
2. The combustion control apparatus as claimed in Claim 1, wherein the combustion controlling actuator includes a fuel injector to inject fuel directly into a combustion chamber of the engine; and the controller is configured to perform a preliminary fuel injection to produce the preliminary combustion at or near top dead center, and to perform a main fuel injection to start the main combustion after the preliminary combustion is finished.
3. The combustion control apparatus as claimed in Claim 2, wherein the controller is configured to control the combustion controlling actuator in a split combustion mode by controlling the fuel injection to produce the preliminary combustion at or near top dead center, and by controlling the fuel injection to start the main combustion after the end of the preliminary combustion when a split combustion request is produced to bring the exhaust purifier to an operative state.

4. The combustion control apparatus as claimed in Claim 3,  
wherein the controller is configured to control the combustion  
controlling actuator normally in a normal combustion mode,  
and to change over a combustion control mode from the  
5 normal combustion mode to the split combustion mode in  
response to the split combustion request produced in  
accordance with a condition of the exhaust purifier.

5. The combustion control apparatus as claimed in Claim 4,  
10 wherein the controller is configured to determine an  
estimated condition of the exhaust purifier and to produce  
the split combustion request in accordance with the  
estimated condition of the exhaust purifier, to request one of  
an increase in an exhaust gas temperature of the engine and  
15 a rich operation of the engine.

6. The combustion control apparatus as claimed in Claim 5,  
wherein the combustion control apparatus further comprises  
a condition sensor to collect information needed to determine  
20 the estimated condition of the exhaust purifying section.

7. The combustion control apparatus as claimed in one of  
Claims 2-6, wherein the controller is configured to delay the  
start of the main combustion with respect to the end of the  
25 preliminary combustion so that premixed combustion process  
is predominant in the main combustion.

8. The combustion control apparatus as claimed in one of  
Claims 2-6, wherein the controller is configured to perform  
30 the main fuel injection for the main combustion at a timing to

start the main combustion after an end of a heat releasing process of the preliminary combustion.

9. The combustion control apparatus as claimed in one of  
5 Claims 2-6, wherein the controller is configured to start the main fuel injection for the main combustion at a timing to inject fuel in a state in which flame subsides in the combustion chamber, to prevent diffusive combustion process in the main combustion.

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10. The combustion control apparatus as claimed in one of Claims 2-6, wherein the controller is configured to control a preliminary fuel injection quantity of the preliminary fuel injection to a smaller quantity required to increase an  
15 incylinder temperature in the combustion chamber, and to make a main fuel injection quantity of the main combustion greater than the preliminary fuel injection quantity, to produce engine torque with the main combustion.

20 11. The combustion control apparatus as claimed in one of Claims 2-6, wherein the controller is configured to control a preliminary fuel injection quantity for the preliminary fuel injection equal to a fuel quantity required to make an incylinder temperature in the combustion chamber at a fuel  
25 injection timing of the main combustion, higher than or equal to an auto ignition temperature enabling spontaneous ignition in the combustion chamber.

12. The combustion control apparatus as claimed in one of  
30 Claims 2-6, wherein an amount of retard of a combustion

start timing of the main combustion with respect to a combustion start timing of the preliminary combustion is equal to or greater than 20° in crank angle.

5 13. The combustion control apparatus as claimed in one of Claims 2-6, wherein an amount of retard of a combustion end timing of the main combustion with respect to compression top dead center is equal to or greater than 50° in crank angle.

10 14. The combustion control apparatus as claimed in one of Claims 2-6, wherein the controller is configured to perform the preliminary fuel injection for the preliminary combustion during a compression stroke.

15 15. The combustion control apparatus as claimed in one of Claims 2-6, wherein the controller is configured to perform the preliminary injection at such a timing as to cause a heat releasing process of the preliminary combustion to start before compression top dead centre and to end after  
20 compression top dead center.

16. The combustion control apparatus as claimed in one of Claims 2-6, wherein the controller is configured to vary at least one of a fuel injection quantity and a fuel injection  
25 timing of the preliminary fuel injection for the preliminary combustion in accordance with a compression end temperature which is a temperature in the combustion chamber at an end of a compression stroke.

17. The combustion control apparatus as claimed in one of Claims 2-6, wherein the controller is configured to control an exhaust gas temperature of the engine by varying the fuel injection timing of the main combustion .

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18. The combustion control apparatus as claimed in one of Claims 2-6, wherein the controller is configured to control the main combustion so as to hold torque produced by the engine constant.

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19. The combustion control apparatus as claimed in one of Claims 3-6, wherein the exhaust purifier includes a particulate filter to collect exhaust particulate matter, and the controller is configured to produce the split combustion request in accordance with an estimated particulate matter quantity of the particulate matter accumulated in the particulate filter, to increase an exhaust gas temperature for auto oxidation of the particulate matter in the particulate filter.

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20. The combustion control apparatus as claimed in one of Claims 3-6, wherein the exhaust purifier includes an NOx trap catalyst device to trap NOx in a lean operation of the engine, and the controller is configured to produce the split combustion request at a time to purify the NOx trapped in the NOx trap device.

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21. The combustion control apparatus as claimed in Claim 20, wherein the controller is configured to produce the split

combustion request in accordance with an estimated NOx quantity of the NOx trapped in the NOx trap device.

22. The combustion control apparatus as claimed in Claim  
5 20, wherein the controller is configured to produce the split combustion request in accordance with a distance traveled by a vehicle powered by the internal combustion engine.

23. The combustion control apparatus as claimed in one of  
10 Claims 3-6, wherein the exhaust purifier includes an NOx trap device to trap NOx in a lean operation of the engine, and the controller is configured to produce the split combustion request at a time to purify sulfur content trapped in the NOx trap device.

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24. The combustion control apparatus as claimed in Claim  
23, wherein the controller is configured to produce the split combustion request in accordance with an estimated sulfur content quantity of the sulfur content trapped in the NOx trap  
20 device.

25. The combustion control apparatus as claimed in Claim  
23, wherein the controller is configured to produce the split combustion request in accordance with a distance traveled by  
25 a vehicle powered by the internal combustion engine.

26. The combustion control apparatus as claimed in one of Claims 3-6, wherein the exhaust purifier includes an NOx trap catalyst device to trap NOx in a lean operation of the engine,

and the controller is configured to produce the split combustion request at a time to warm up the NOx trap device.

27. The combustion control apparatus as claimed in one of  
5 Claims 1-6, wherein the controller is configured to perform a plurality of preliminary fuel injections to cause a plurality of heat releasing processes for the preliminary combustion prior to the main combustion so that at least one of the heat realizing processes of the preliminary combustion is produced  
10 at or near top dead center.

28. The combustion control apparatus as claimed in Claim 27, wherein the controller is configured to perform a plurality of preliminary fuel injections to cause a plurality of heat  
15 releasing processes for the preliminary combustion in a low engine load region.

29. The combustion control apparatus as claimed in one of Claims 1-6, wherein the combustion control apparatus further  
20 comprises the internal combustion engine which is a diesel engine.

30. A combustion control process for an internal combustion engine provided with an exhaust purifier in an exhaust  
25 passage of the internal combustion engine, the combustion control process comprising:

controlling fuel injection to produce preliminary combustion in an engine cycle; and

controlling fuel injection to start main combustion after  
30 an end of the preliminary combustion in the engine cycle.

31. The combustion control process as claimed in Claim  
determining an estimated condition of the exhaust  
purifier;

5       producing a split combustion request in accordance with  
the estimated condition of the exhaust purifier;

          changeover a combustion control mode from a normal  
mode to a split combustion mode in response to the split  
combustion request; and

10       controlling the fuel injection to produce the preliminary  
combustion and the fuel injection to start the main  
combustion after the end of the preliminary combustion in  
the split combustion mode.

15   32. A combustion control apparatus for an internal  
combustion engine, comprising:

          means for determining an estimated condition of the  
exhaust purifier;

          means for producing a split combustion request in  
20   accordance with the estimated condition of the exhaust  
purifier; and

          means for controlling fuel injection to the engine in a  
split combustion mode in response to the split combustion  
request by controlling fuel injection to produce preliminary  
25   combustion and controlling fuel injection to start main  
combustion after an end of the preliminary combustion.